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1725  
 #  
 Attorney Docket No. W1010.136-US-01  
 [Formerly: 134.140]

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 MAR 03 2003  
 GROUP 1700 AMENDMENT TRANSMITTAL

In re the application of:

Kazuo OSHNISH; Toshimi ABUKAWA;  
 Masafumi SAKAMOTO; Koki ISOZAKI

Confirmation No.: 1725

Application No.: 10/082,000

Examiner: Hanh N. NGUYEN

Filed: 02/22/2002

Group Art Unit: 2834

For: THREE-PHASE HYBRID TYPE STEPPING MOTOR

Assistant Commissioner for Patents  
 Washington, D.C. 20231

Sir:

Transmitted herewith is an Amendment in the above-identified application.

[ ] Applicant(s) is/are entitled to small entity status in accordance with 37 CFR 1.27.

The filing fee has been calculated as shown below:

	Claims Remaining After Amendment	Highest No. Previously Paid For	Present Extra (Equals)	Small Entity Rate	Add'l Fee	OR	Large Entity Rate	Add'l Fee
Total	12	- 8	= -0-	x 9	\$		x 18	\$
Indep.	4	- 2	= 1	x 42	\$		x 84	\$84.00
Mult. Dep.			=	+ 140	\$		+ 280	\$
				TOTAL	\$	OR	TOTAL	\$84.00

[ ] First Presentation of Multiple Dependent Claim [MDC]

- \* If the entry in Column 1 is less than the entry in Column 2, write "0" in Column 3.
- \*\* If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, write "20" in this space.
- \*\*\* If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, write "3" in this space.
- The "Highest Number Previously Paid For" (Total or Independent) is the highest number found from the equivalent box in Column 1 of a prior Amendment or the number of claims originally filed.

Application No. 10/082,000

[x] A check in the amount of \$84.00 is attached. The Commissioner is hereby authorized to charge payment of any fees under 37 C.F.R. § 1.16 for presentation of extra claims or credit any overpayment to Deposit Account No. 50-2522.

Respectfully submitted,

*Julie Zavoral*

Julie A. Zavoral  
Attorney for Applicant(s)  
Registration No. 43,304

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*Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 50-2522*

**CERTIFICATE OF MAILING**

I hereby certify that this document is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on 18 February 2003.

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Printed Name

*J-White*

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TC 2800 MAIL ROOM



PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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AMENDMENT

Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir:

In response to the Office Action of October 17, 2002, and in accordance with the automatic extension of time for response provided by 37 C.F.R. § 1.136(a), amendment to the above-identified patent application is requested as follows:

IN THE SPECIFICATION

Please substitute the following amended paragraph(s) and/or section(s):

Page 2, Paragraph 3, after line 15, please insert the following:

SUMMARY OF THE INVENTION

An object of the present invention is to provide a three-phase hybrid type stepping motor invention comprises a stator, and a rotor arranged concentrically with the stator and with an air gap therebetween, said stator having an annular stator yoke, six stator poles extending radially and formed at a regular pitch on the inner peripheral surface of the annular stator yoke, and stator windings of three-phase each wound around each stator pole, each of said stator poles having a plurality of small stator teeth at the tip end thereof, said rotor having two splitted rotor elements and a permanent magnet held therebetween and magnetized so as to form N and S poles in the

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Applicants: Kazuo OSHNISHI, et al.

Serial No.: 10/082,000

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axial direction thereof, and a plurality of small rotor teeth formed at a regular pitch on the outer peripheral surface of each of said rotor elements, said two splitted rotor elements being shifted from each other in angular position by a  $\frac{1}{2}$  pitch of the small rotor teeth. A permeance distribution of the small stator teeth is a vernier pitch balanced by a six order harmonic wave, and a tooth width ratio of the small rotor teeth with the small stator teeth is set to 0.35 - 0.45.

Another object of the present invention is to provide a three-phase hybrid type stepping motor wherein a permeance distribution of the small stator teeth is a vernier pitch balanced by a three order harmonic wave, and a tooth width ratio of the small rotor teeth with the small stator teeth is set to 0.35 - 0.45.

A further object of the present invention is to provide a three-phase hybrid type stepping motor, wherein a number of the small rotor teeth is fifty, a number of the small stator teeth is eight, a tooth pitch is 7.05, and a tooth width ratio of the small rotor teeth with the small stator teeth is set to 0.35 - 0.45.

A still further object of the present invention is to provide a three-phase hybrid type stepping motor, wherein the three-phase windings of the stator are connected in the form of delta.

These and other objects and features of the present invention will become apparent from the following description in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a vertically sectional front view of a conventional three-phase hybrid type stepping motor with twelve poles having windings;

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FIG. 1B is a vertically sectional left side (N pole side) view of a conventional three-phase hybrid type stepping motor shown in FIG. 1A;

FIG. 1C is a vertically sectional right side (S pole side) view of a conventional three-phase hybrid type stepping motor shown in FIG. 1A;

FIG. 2A is a vertically sectional front view of a conventional three-phase hybrid type stepping motor with six poles having windings;

FIG. 2B is a vertically sectional left side (N pole side) view of a conventional three-phase hybrid type stepping motor shown in FIG. 2A;

FIG. 2C is a vertically sectional right side (S pole side) view of a conventional three-phase hybrid type stepping motor shown in FIG. 2A;

FIG. 3 is an explanation view of a stator core of a three-phase hybrid type stepping motor with six poles having windings and a stator core of a three-phase hybrid type stepping motor with twelve poles having windings;

FIG. 4A is an explanation view of a wiring system of a three-phase hybrid type stepping motor with six poles having windings;

FIG. 4B is an explanation view of a wiring system of a three-phase hybrid type stepping motor with six poles having windings;

FIG. 5 is a diagram showing characteristic features of the cogging torque, magnetic flux, and distortion rate of the magnetic flux wave form of the three-phase hybrid type stepping motor with six poles having windings; and

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FIG. 6 is a diagram showing characteristic features of the cogging torque, magnetic flux, and distortion rate of the magnetic flux wave form of the three-phase hybrid type stepping motor with six poles having windings.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

On Page 3, paragraph 3, lines 23-25:

Here,  $n_1$  denotes a total number of winding turns of one phase,  $\Phi$  denotes a magnetic flux of the magnet passing through one turn of windings,  $\omega$  denotes an angular velocity of the rotor, and  $\theta = \omega t$ .

On Page 4, paragraph 3, lines 12-19:

According to the Formula 3, it is noted that the induced voltage is in proportion to the number of  $n_1$  of winding turns, the number  $p$  of rotor teeth, the angular velocity  $\omega$ , and the magnetic flux  $\Phi$ , respectively. On the other hand, an electrical input is  $e_1 \times i_1$  when a current is passed through a winding which generates the induced voltage  $e_1$ . The electrical input is equal to a mechanical output (torque  $\tau_1 \times$  angular velocity  $\omega$  of rotor) of one phase as expressed by Formula 4.

On Page 6, Equation 8, lines 21-24:

$$L_1 = \frac{\text{number of series windings of one phase}}{\text{number of parallel windings of one phase}} \times \\ (\text{number of winding turns of one pole})^2 \times$$

$$\text{permeance of one pole} = \frac{n_s}{n_p} \left( \frac{n_1}{n_w / m} \right)^2 \frac{P_T}{n_w} \quad \dots(8)$$

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On Page 8, after Table 2, line 20, please insert:

The vernier pitch  $\theta_v$  can be expressed by Equation 9:

$$\theta_v = \frac{360}{p} \pm \frac{360}{pnQ} \text{ (deg rees)} \quad \dots \text{Equation 9}$$

where  $p$  is the pole pair number, such as 50,  $n$  is the cancellation order and  $Q$  is small tooth number.

On Page 9, paragraph 3, lines 17-25:

In the three-phase motor, the balance harmonic wave for minimizing the cogging torque is six order, but the normal motor is four order, so that it is considered that the balance harmonic wave of three order is effective to reduce the tertiary harmonic wave. Accordingly, the cogging torque, magnetic flux, and rate of distortion of the magnetic flux are calculated with respect to four kinds items including one having no vernier. The ratio of the width of the stator pole tooth to the rotor small tooth pitch is set to .4 which is considered as the best. It is judged that the six order balance is the best in consideration of each performance totally.

Please cancel all paragraphs beginning on Page 10, line 20 through Page 13, line 17.

On Page 10, paragraph 1, lines 1-5:

The width of the pole tooth in the optimum six order vernier system is considered. FIG. 6 shows results of the calculation concerning the small tooth wherein the tooth width of the rotor is considered as the same as that of the stator in order to simplify the calculation. As shown in FIG. 6, the ratio of the small tooth width to rotor teeth pitch of 0.35 - 0.45 is most preferable and among the above ratios the ratio of about 0.4 is considered as the best.

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On Page 13, paragraph 6, lines 20-25 bridging Page 14, lines 1-12:

A three-phase hybrid type stepping motor according to the present invention comprises a stator 5 and a rotor 9 arranged concentrically with the stator 5 and with an air gap therebetween, said stator 5 having an annular stator yoke 1, a plurality of stator poles 2 extending radially and formed at a regular pitch on the inner peripheral surface of the annular stator yoke 1, a plurality of stator poles 2 extending radially and formed at a regular pitch on the inner peripheral surface of the annular stator yoke 1, stator windings 3 of three-phase each wound around each stator pole 2, each of said stator poles 2 having six small stator teeth 4 at the tip end thereof, said rotor 9 having two splitted rotor elements 7 and a permanent magnet 8 held therebetween and magnetized so as to form N and S poles in the axial direction thereof, and fifty small rotor teeth 6 formed at a regular pitch on the outer peripheral surface of each of said rotor elements 7, said two splitted rotor elements 9 being shifted from each other in angular position by  $\frac{1}{2}$  pitch of the small rotor teeth 6. A permeance distribution of the six small stator teeth 4 is a vernier pitch balanced by six order harmonic wave, and a ratio of the tooth width of the small stator teeth 4 with the pitch of the small rotor tooth set to 0.35 – 0.45.

On Page 14, paragraph 1, lines 13-16:

In a further embodiment of the present invention, a permeance distribution of the six small stator teeth 4 is a vernier pitch balanced by three order harmonic wave, and a ratio of the tooth width of the small stator teeth 4 with the pitch of the small rotor tooth is set to 0.35 – 0.45.

On page 14, paragraph 2, lines 17-20:

In a further embodiment of the present invention, a number of the small stator teeth 4 is eight, a tooth pitch is 7.05, and a ratio of the small stator teeth 4 to the pitch of the small rotor tooth is set to 0.35 – 0.45.